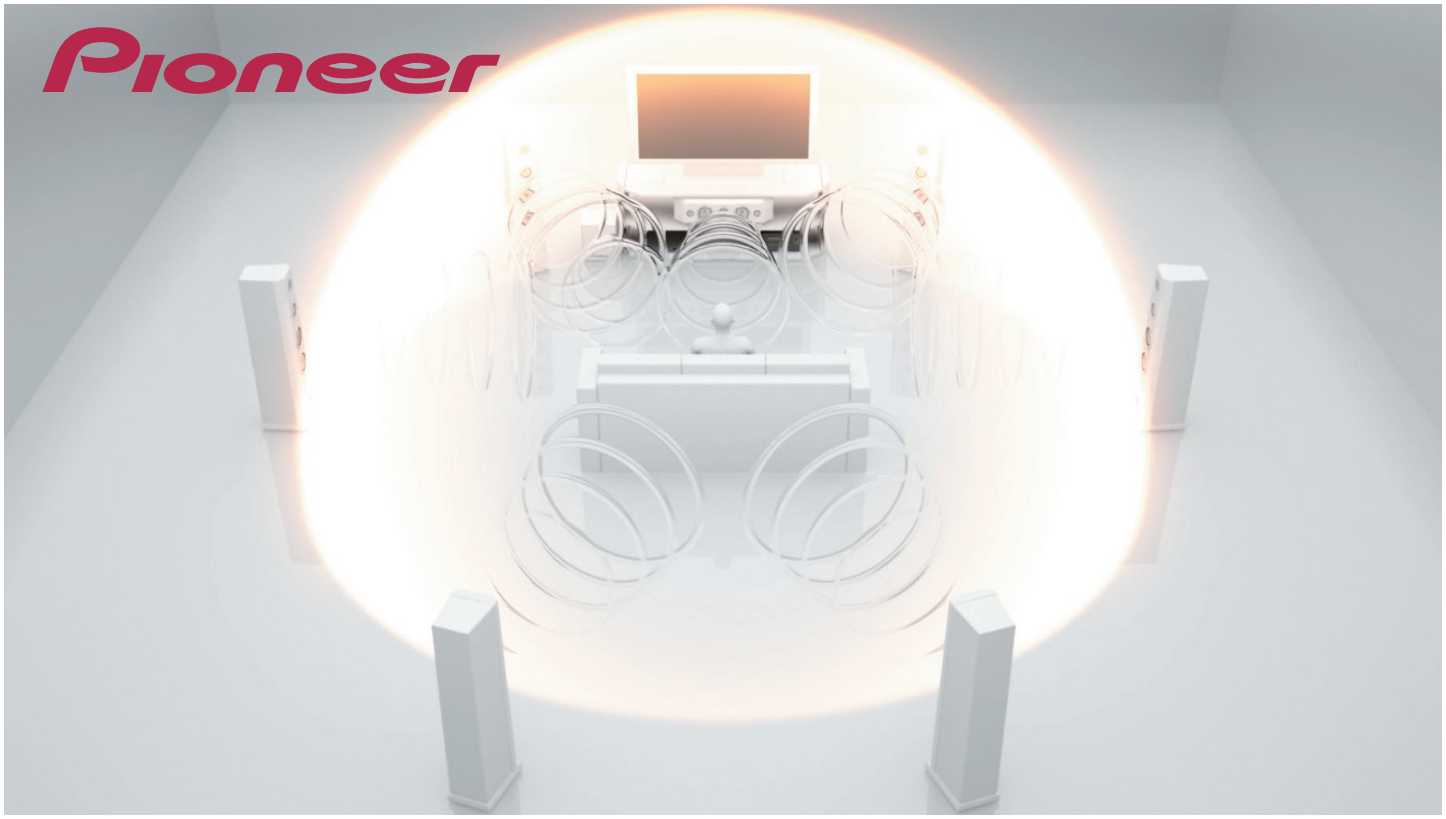


MCACC (Multi-Channel ACoustic Calibration system) Reference Guide

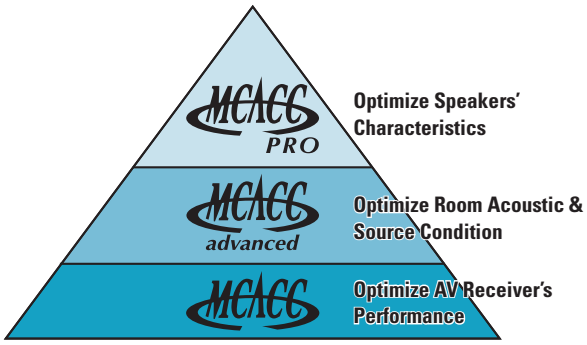
- Introduction
  - MCACC
  - Advanced MCACC
  - MCACC Pro
- The Essence of MCACC
  - Phase Characteristic
  - Measurement Precision
  - Reproduction Frequency
- MCACC
- Advanced MCACC
- MCACC Pro
- MCACC/Advanced MCACC/MCACC Pro Feature Comparison
- Technical Details

Introduction

MCACC Overview

To get the best results from a home theater system, it needs to be fine-tuned, just like a musical instrument, for accurate reproduction of sound as the original artists intended. Yet, this is no easy task in a household multi-channel environment with all the speakers, furniture, the size and shape of the room, and various other issues. That's why Pioneer developed MCACC (Multi-Channel ACoustic Calibration system), a unique system which measures and analyses the reverb characteristics of the speakers, and optimally tunes the sound output to make it just right for the room.

MCACC was originally introduced in 2001 as the world's first automatic sound acoustic correction technology. With the addition of Phase Control technology which compensates the phase lag of the low-frequency signals, multi-channel sound is now further optimized to bring out the best from your home theater. MCACC is now available at three levels—MCACC, Advanced MCACC, and MCACC Pro—in accordance with the grade of the AV receiver.



MCACC—Basis of Acoustic Field Correction

With a dedicated microphone, MCACC measures the speaker size, level, and distance and automatically compensates for the difference. The delay of the subwoofer sound is also adjusted to be in phase with the other channels.

Details on page 5

Advanced MCACC—Precise Speaker Drive and Advanced Correction for the Listening Environment

Advanced MCACC features a 3D calibration method with even more precise measurements by including the time axis, as well as Auto Phase Control Plus for real-time analysis and automatic compensation, Standing Wave Control for reducing unwanted resonance, and Subwoofer EQ for adjusting the LFE tone.

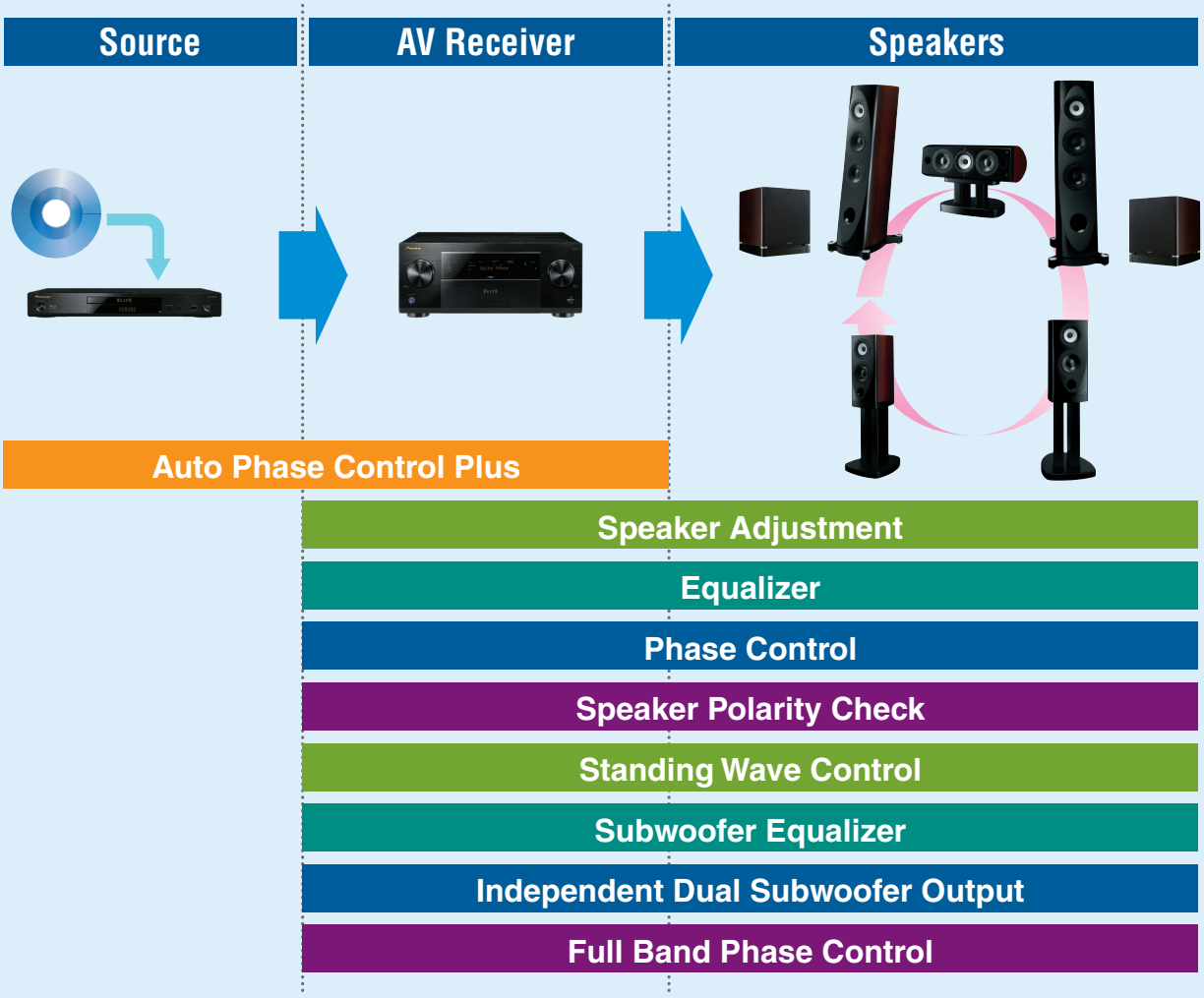
Details on page 6

MCACC Pro—Professional Level Correction from Source Material to Speaker Output

In addition to the above features, MCACC Pro goes a step further by analyzing the phase and group delay characteristics due to network filtering to precisely control phase differences between speakers. The result is the sound coherence of full-range speakers while retaining the wide frequency range advantage of multi-way speakers. This correction is also performed between channels, providing a smooth flow of sound as if all delivered from the same type of speaker. Other features include independent correction for dual subwoofers, and speaker position adjustment in 1-millimeter increments. MCACC Pro corrects phase differences in all ranges and all channels, from phase difference in the original audio material to the sound emitted from the speakers.

Details on page 8

MCACC—Acoustic Field Correction at All Levels



The Essence of MCACC

Pioneer is dedicated to making your home theater experience as close as possible to what the sound creators and studio engineers intended when they created the original sound tracks. Developed through a rigorous pursuit of the ideal multi-channel audio reproduction, the MCACC technology focuses on three main features—phase characteristic, measurement precision, and reproduction frequency—which sets it apart from other similar technologies.

Phase Characteristic

When audio signals are out of phase, cancelling out of sound occurs between speaker units and channels, and the original sound cannot be reproduced. Pioneer's MCACC can make adjustments without altering the phase characteristics, thereby allowing original sound reproduction just as the creator intended.

More details on page 12

Measurement Precision

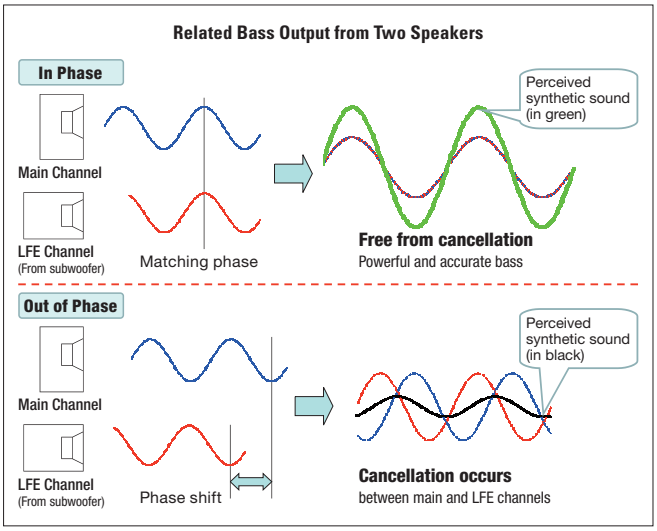
In a normal living room environment, the reverberation characteristic is inconsistent due to various interior materials and furniture placement. So the optimum sound quality cannot be achieved if the EQ is based on measurement data that includes reverberant sound. The measurement for Pioneer's MCACC takes the time-axis into account and applies different compensation methods according to the influence of the reverberant sound, enabling optimal compensation for the listening environment.

More details on page 13

Reproduction Frequency

When EQ adjustment is applied to high-resolution audio sources, the sound quality cannot be maintained if the reproduction frequency is reduced from the original 192 kHz or 96 kHz level. Pioneer's MCACC makes EQ adjustment without changing the audio file's reproduction frequency, allowing playback of true high-resolution sound in a multi-channel setup.

An Example of the Phase Problem

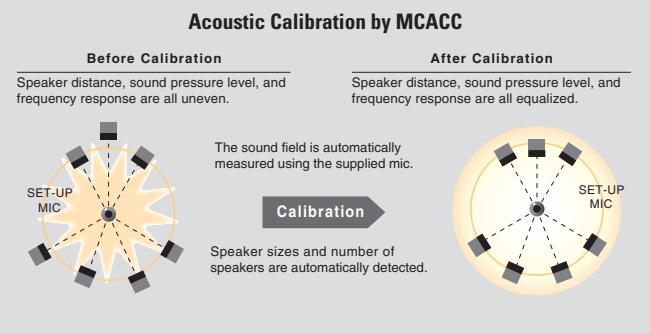


MCACC

Speaker Adjustment (size, level, distance, crossover)

Create the optimum acoustic environment with Pioneer's MCACC, developed with the expertise of professional recording studios. The system — complete with custom microphone — automatically compensates for differences in speaker size, level and distance, and equalizes response.

More details on page 11


Acoustic Calibration by MCACC
Before Calibration
Speaker distance, sound pressure level, and frequency response are all uneven.
After Calibration
Speaker distance, sound pressure level, and frequency response are all equalized.
SET-UP MIC
The sound field is automatically measured using the supplied mic.
Calibration
Speaker sizes and number of speakers are automatically detected.
SET-UP MIC

Equalizer

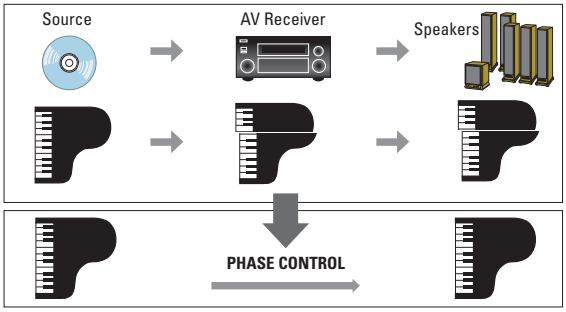
The frequency response of each speaker is measured and adjusted for all bands. This is completed with the original Envelope Compensation applied technology, which ensures optimum timbre-matching with minimum phase variation among channels.

More details on page 12

Phase Control

When amplifying multi-channel audio signals, receivers use a Low Pass Filter (LPF) to process low-frequency signals for subwoofer output. This causes "phase lag" — a delay of approximately 5 msec — of the low-frequency signals compared to the main channel signals. As a result, the delayed bass makes the sound lack synchronization. Pioneer's Phase Control technology effectively eliminates phase lag and significantly improves the multi-channel sound without any extra operation.

The "Phase Control" Compensates for the Delay of Low-Frequency Sound



Problems occur even with an ideal content which has no LFE delay. Phase Control solves this within the AV receiver.

Advanced MCACC

Speaker Adjustment (size, level, distance, crossover)

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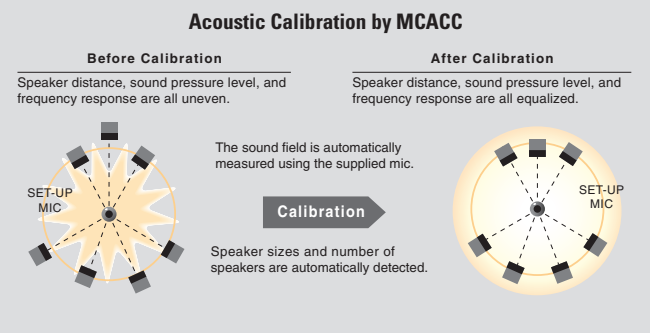
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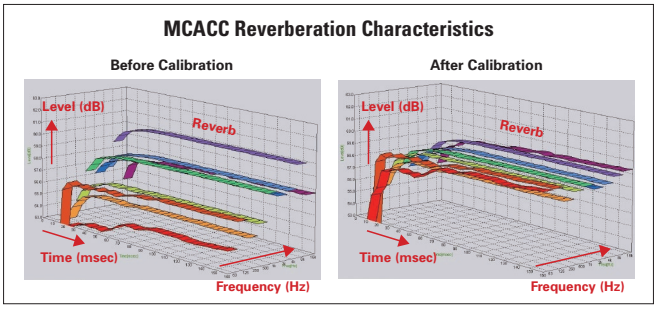
More details on page 12



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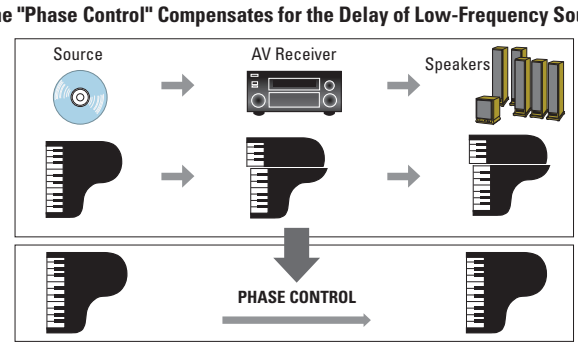


Problems occur even with an ideal content which has no LFE delay. Phase Control solves this within the AV receiver.

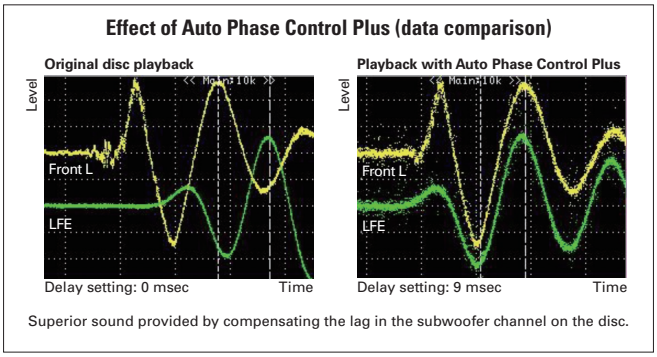
Auto Phase Control Plus

During Blu-ray Disc/DVD/multi-channel file playback, Auto Phase Control Plus makes real-time analysis of the phase difference between the LFE (low frequency effect) and the main signals, and automatically compensates the gap. Elimination of phase lag enhances strong bass and clear high-frequency sound — especially effective for audio content such as live performance and music video clips.

Auto Phase Control Plus

*** Effectiveness depends on content**

More details on page 13



Superior sound provided by compensating the lag in the subwoofer channel on the disc.

Speaker Polarity Check

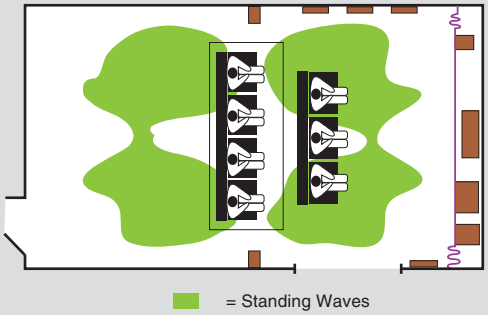
The Advanced MCACC will check the speaker polarity for proper connection. "Reverse Phase" will be displayed on the GUI screen if the speaker's wiring (+ and -) is inverted.

Standing Wave Control

Acoustic standing waves occur when the sound waves from your speaker resonate with those reflected off the walls. Depending on the speaker placement, your listening position or the shape of the room, standing waves have a negative effect on the overall sound, especially in certain lower frequencies. Standing Wave Control effectively decreases resonance and prevents inaccurate EQ-setting calibration.

More details on page 14

Standing Wave in a Typical Listening Room



Subwoofer Equalizer

This new EQ feature allows you to adjust the subwoofer tone. For Auto MCACC, the subwoofer EQ is automatically adjusted with EQ type ALL CH ADJ, while manual adjustment is available with EQ type SYMMETRY and FRONT ALIGN. As with other EQ, the manual adjustment can be done on the AV receiver's GUI.

MCACC Pro

Speaker Adjustment (size, level, distance, crossover)

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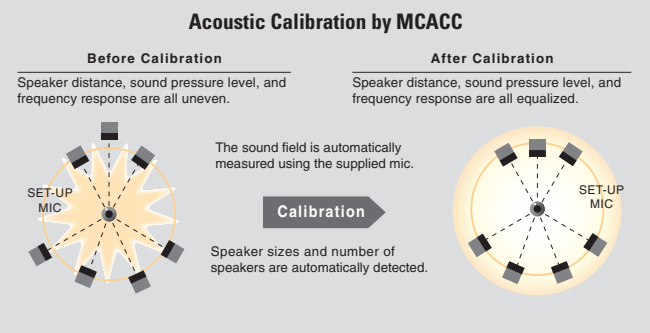
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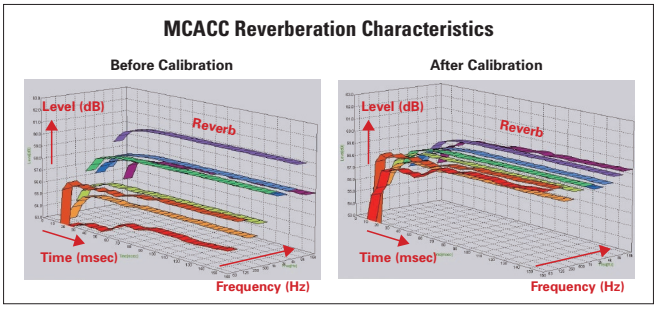

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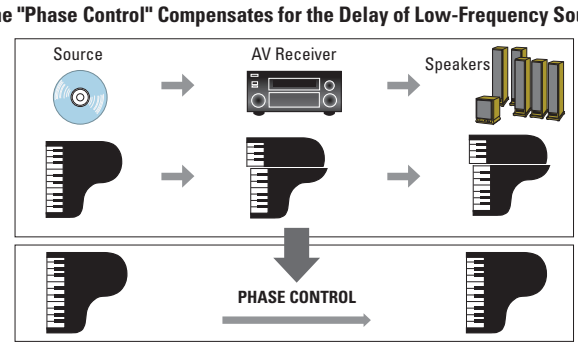

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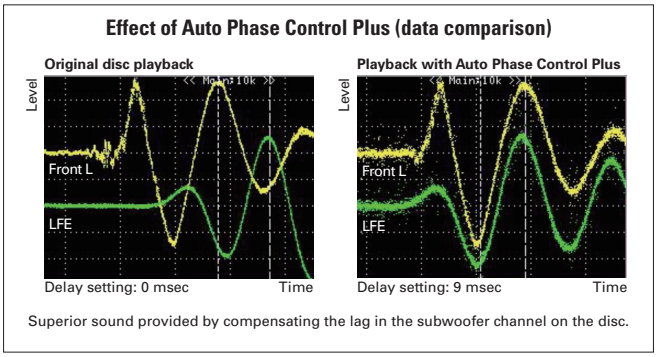

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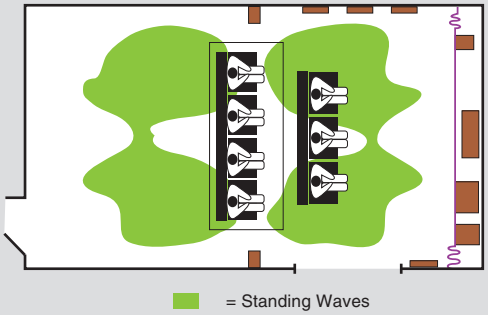

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Independent Dual Subwoofer Output

When connecting an additional subwoofer to increase the bass, the two subwoofers may not be at a same distance. In such a case, cancelling out of the bass may occur and prevent you from perceiving the full effect of the additional subwoofer. MCACC Pro supports independent adjustment for each subwoofer, offering optimal performance for a dual-subwoofer setup. You can enjoy free placement of your subwoofers.

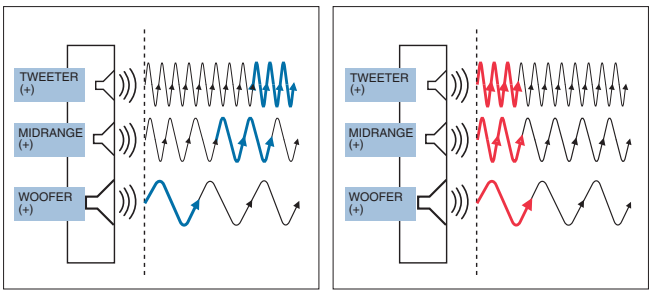
Full Band Phase Control

The further advanced Full Band Phase Control technology focuses on the group delay in the speaker network filter, and compensates with special digital signal processing (DSP), to adjust the phase of each unit as well as the group delay for each speaker. Full Band Phase Control gives multi-range speakers the sound coherence of full-range speakers, while retaining the wide frequency range advantage.

More details on page 15

Full Band Phase Control Off

Full Band Phase Control On

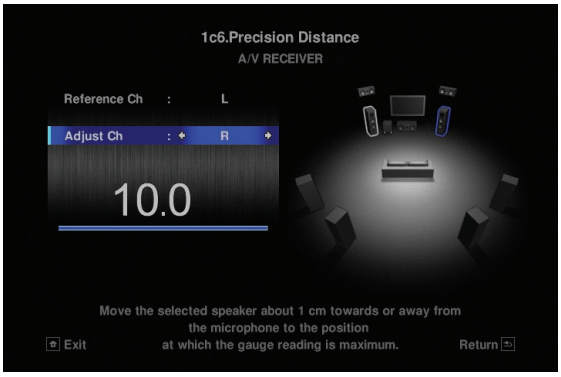


Adjusts group delay for each unit

Precision Distance

Precision Distance is an innovative, world's first feature for making millimeter-level manual adjustments to speaker distance. You can easily duplicate a skilled installer's precise positioning with the help of a level gauge shown on the display.

* Only available for some models


1c6.Precision Distance
A/V RECEIVER
Reference Ch : L
Adjust Ch : R
10.0
Move the selected speaker about 1 cm towards or away from the microphone to the position at which the gauge reading is maximum.
Exit
Return

MCACC/Advanced MCACC/MCACC Pro Feature Comparison

	MCACC Pro	Advanced MCACC	MCACC
Speaker Adjustment (size, level, distance, crossover)	•	•	•
Equalizer	3D	3D	2D
Phase Control	•	•	•
Auto Phase Control Plus	•	•	—
Speaker Polarity Check	•	•	—
Standing Wave Control	•	•	—
Subwoofer Equalizer	•	•	—
Independent Dual Subwoofer Output	•	—	—
Full Band Phase Control	•	—	—
Precision Distance	•	—	—

Technical Details

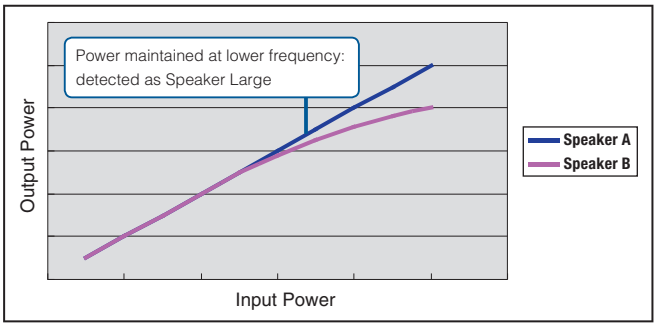
Speaker Adjustment

MCACC applies the most suited test signal for each item to make measurements.

Speaker Size Detection

With MCACC, the speaker size is detected by a general method using frequency characteristics. In addition to the measurement by MCACC, Advanced MCACC and MCACC Pro check the linearity, and more precisely measures the ability for low frequency playback.

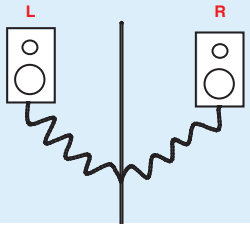
Low Frequency Linearity Measurement



Speaker Distance Adjustment

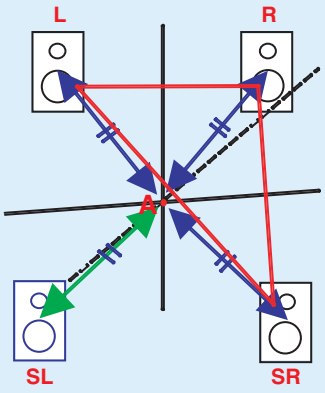
Why does precise adjustment of the speaker distance improve the balance of the whole sound field in your listening space? That's because with a multi-channel speaker system, a single speaker placed at a different distance from the other speakers can have an adverse effect to all the other speakers, and distort the sound field for the whole system, as shown on right. In reverse, if all the speakers are at an equal distance, the phase will be aligned. As a result, the sound improves not only at the listening spot where the microphone is placed, but also in the whole listening area by optimized balance of the sound field.

Pioneer is one of the few manufacturers providing speaker distance measurement in 1 cm-increment. What's more, Pioneer's Precision Distance is the only technology allowing millimeter-level manual adjustment to the speaker distance.



With a 2ch system, all points on the bisector are at equal distance

On a stereo system, a set of points with equal distance from the two speakers becomes a straight line as shown on left. So it is relatively easy to gain the point where the sound waves from all sound sources (two speakers) intersect in phase.



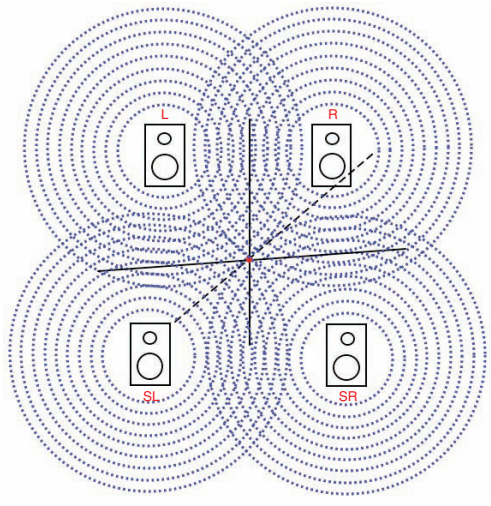
With a 3ch system, the intersection of two bisectors needs to be at an equal distance

With a 3ch system, the intersection of the bisector between L and R and the bisector between R and SR, point A, is where the sound wave from all sound sources intersects in phase, as shown with a red triangle. The bisector between L and SR automatically passes through this point.

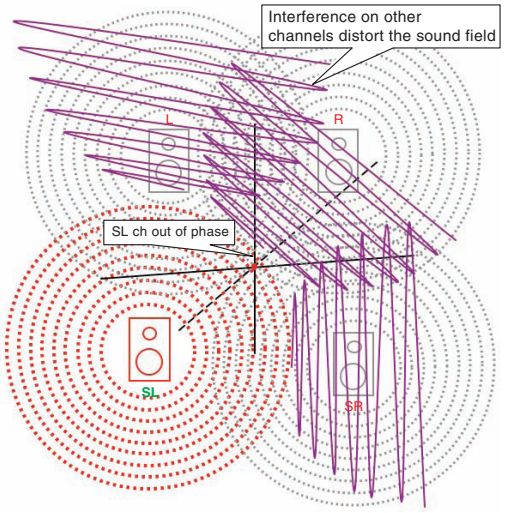
With a 4ch system, the additional channel must precisely match the point fulfilling the condition for 3ch

With 4 or more channels, the distance for the additional channel(s) (shown with the green arrow) must precisely match the already affixed point A for 3ch. So it becomes more difficult to achieve the point where the sound waves from all sound sources intersect in phase.

The ideal is to have a spot with the same acoustic distance from all speakers



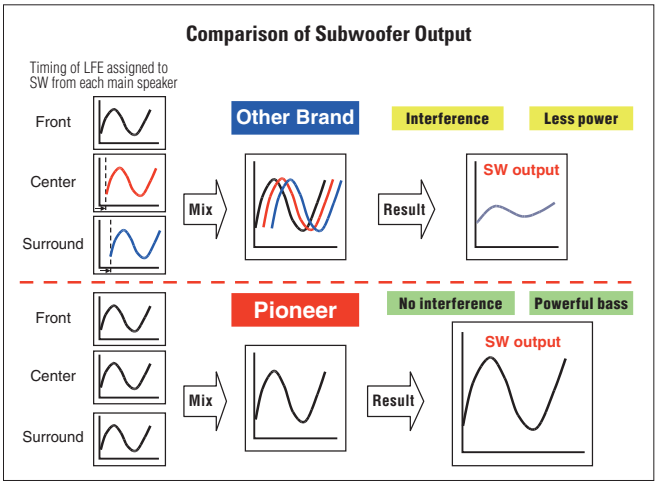
All channels are in phase, with ideal sound field for all channels



Distorted overall sound field

Crossover Frequency Adjustment

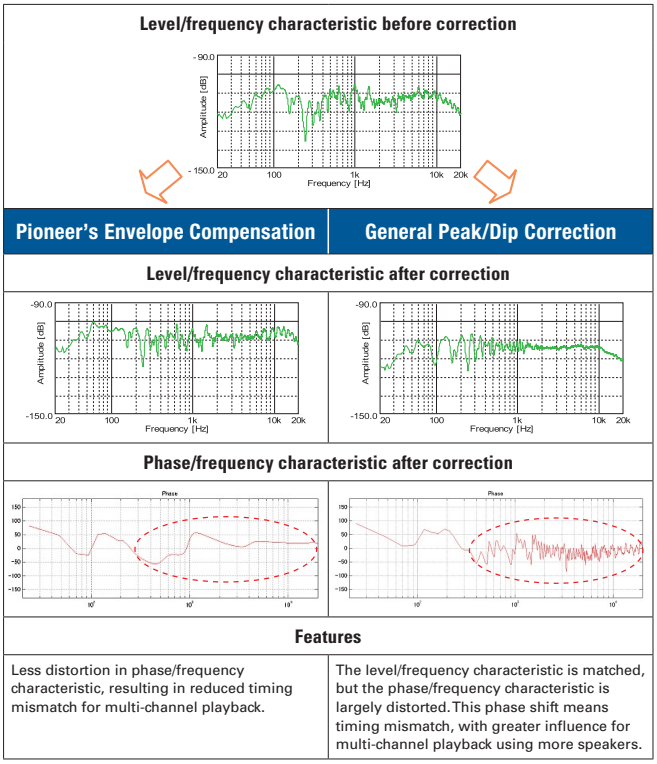
Using the measured result, one suitable parameter is set for all the speakers. This helps to prevent cancelling out of the bass sound caused by a phase shift. Other manufacturers use separate filters for each channel. This is fine when all the speakers are of the same type, but with various types of speakers, the timing of the bass will be inconsistent, causing cancelling out with a loss of the bass sound.



Equalizer (Frequency Characteristic Adjustment)

The frequency characteristic for each channel is adjusted using the 9-band EQ, which has minimal effect on the phase characteristic while achieving optimum performance. As shown on right, the general peak/dip correction method is good at matching the frequency characteristics, but making detailed adjustments on every peak and dip for each speaker will cause phase shifts and deteriorate sound localization. In contrast, Pioneer's MCACC performs a frequency characteristic adjustment using the Envelope Compensation technology with low Q filter. This minimizes the effect on the phase, providing a natural and smooth adjustment in a multi-channel playback environment.

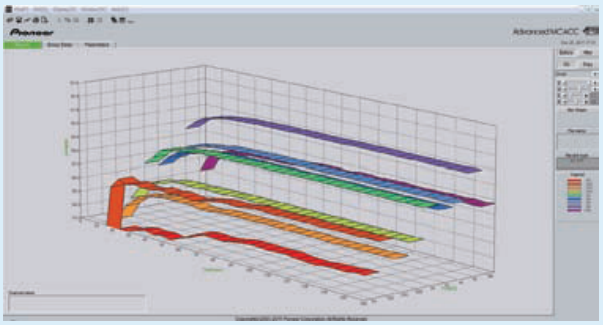
Pioneer's Envelope Compensation vs. Peak/Dip Correction


Level/frequency characteristic before correction
Amplitude [dB]
Frequency [Hz]
Pioneer's Envelope Compensation
General Peak/Dip Correction
Level/frequency characteristic after correction
Phase/frequency characteristic after correction
Features
Less distortion in phase/frequency characteristic, resulting in reduced timing mismatch for multi-channel playback.
The level/frequency characteristic is matched, but the phase/frequency characteristic is largely distorted. This phase shift means timing mismatch, with greater influence for multi-channel playback using more speakers.

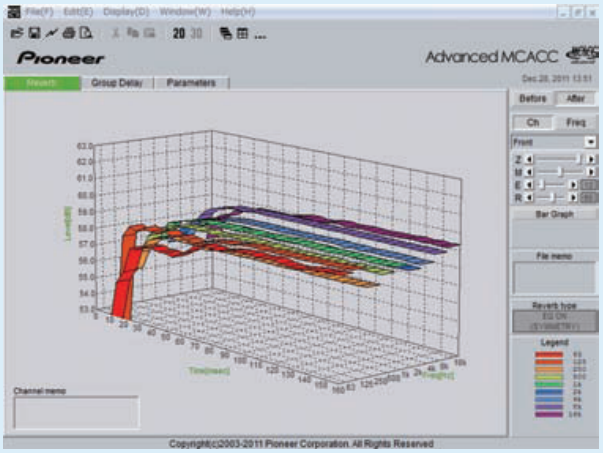
3D Time-Axis Compensation

As shown on the 3D graphs on right, the frequency characteristics change with the passing of time. So if compensation is made on the same point of the time-axis, there will be some difference due to reverberation. To solve this problem, Advanced MCACC adopts the 3D Time-Axis Compensation which takes into account this change along the time-axis. You can measure the listening environment before correcting the sound field, and make compensations matched to the condition. The adjustment can be done in 0 to 160 msec range including the direct sound area, allowing compensation with emphasis on direct sound. The adjustment point can be controlled manually for minute adjustments suited to the listening environment. The measured results can be displayed in a rotatable 3D graph on your personal computer or iPad via the AVNavigator or iControlAV5 app. Anyone can easily use the professional features such as display before/after calibration comparison, or check if each frequency characteristic is aligned at the setup point on the time-axis.

Before Calibration



After Calibration

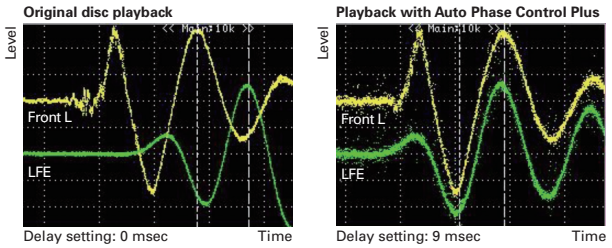


Advanced MCACC Reverberation Measurement Result

Auto Phase Control Plus

Multi-channel sounds on Blu-ray Discs, DVDs, or 5.1ch WAV/FLAC are sometimes recorded with LFE channel delay (about max. 16 msec) caused by the LPF (low-pass filter) when the discrete sounds are packaged. This delay in the low frequencies affects not only the bass, but also the main channel playback, dulling the rhythm and sound. During playback, Phase Control Plus technology automatically adjusts and compensates the phase lag (group delay) included in the sound source, from 0 to 16 msec in 1 msec increments. In addition to solving the phase lag (group delay) in audio devices such as AV receivers and speakers, the phase shift sometimes included in discs or broadcasts can also be adjusted, allowing precise control of every phase, from audio source to output. With the synergy effect of the original Phase Control compensation, all sounds are aligned, providing better balance for the overall reproduced sound, exceptionally powerful and dynamic bass, and clear high frequencies.

Effect of Auto Phase Control Plus (data comparison)

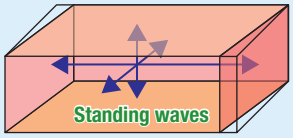


Superior sound provided by compensating the lag in the subwoofer channel on the disc.

Standing Wave Control

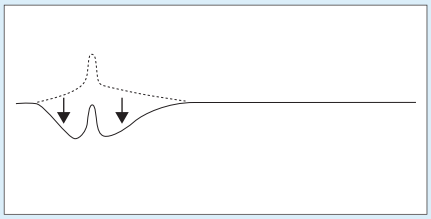
In a normal room, standing waves occur between parallel surfaces such as ceiling/floor and facing walls; a factor that greatly influences sound quality. The standing waves in the low frequency range are especially difficult to control with general sound processing methods, and there was no way but to listen to the negatively-affected sound. Advanced MCACC captures up to three largest standing waves, and applies compensation curves with the opposite characteristics to eliminate the influence.

In a regular shaped room, standing waves occur between the ceiling and the floor, and between the walls

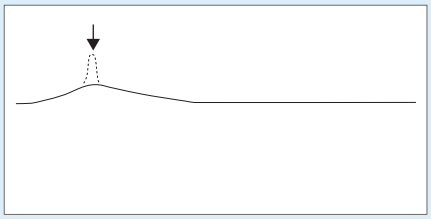


With Advanced MCACC, the EQ compensation curve is moderately set (Envelope Curve), and is not suited to adjusting a certain frequency like standing waves. For Standing Wave Control, a filter with a steep correction curve is used to avoid over-compensating the effects of the standing waves.

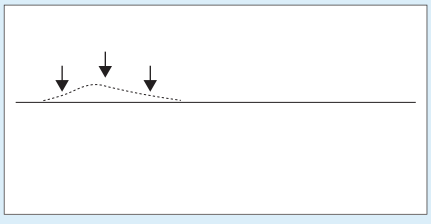
EQ Overcompensation Example
(no standing wave control)



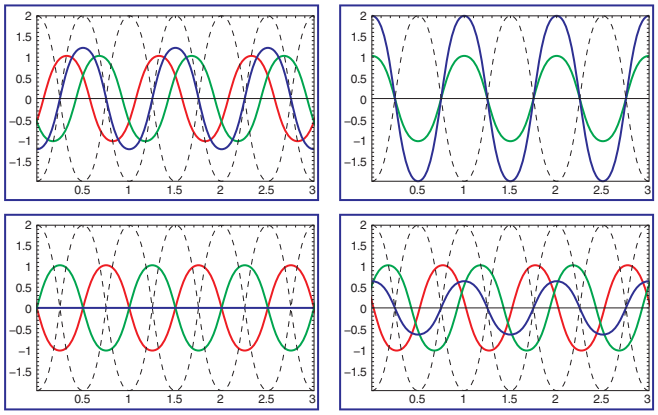
Pioneer's EQ adjustment uses the Envelope Compensation method with emphasis on phase characteristics. Since a low Q filter is applied, if standing waves exist in a certain frequency, the surrounding frequencies are also affected during the adjustment. As a result, the volume of the bass sound may be overly reduced.



So first using a compensation filter pinpointing on a specific frequency, only the standing waves are lowered.

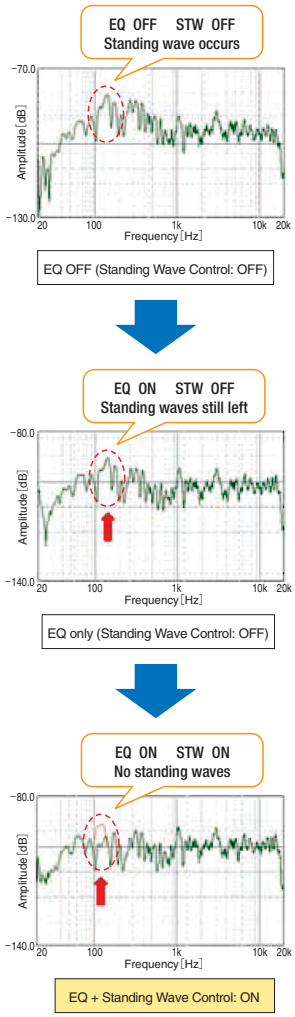


Then, EQ adjustment is applied after Standing Wave Control. In this way, frequency characteristic adjustment is done without reducing the volume of the bass.



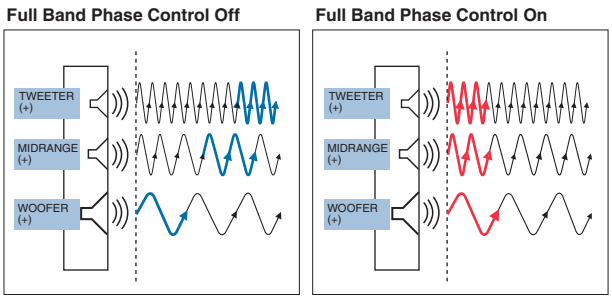
Standing wave: When the sound wave emitted from the speaker reflects off the wall, ceiling, or floor, the incident wave and reflected wave interfere and cause a phenomenon that intensifies or weaken the wave. In such cases, standing waves occur at a certain distance from the reflecting surface. Standing waves have nodes and antinodes, with minimum amplitude at a node, and maximum amplitude at an antinode. On the graphs, incident wave is in red, reflected wave in green, the added total wave in blue. The four graphs show chronological changes, with the horizontal axis representing points. For example, the blue wave's amplitude at 0.75 point from left remains unchanged at 0 (node), even as the time passes and the incident wave's amplitude changes. The amplitude becomes maximum at points 0.5 or 1 for example, thus creating an antinode.

Effects of Standing Wave Control



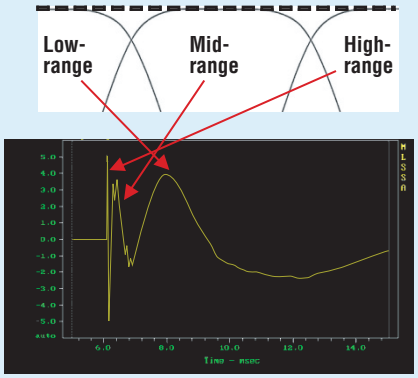
Full Band Phase Control

While Phase Control's bass management technology controls the LFE channel timing and phase within the AV receiver, the Full Band Phase Control's technology has further evolved to control the phase of all the units of the multi-way speaker system. With a normal multi-way speaker system, the audio signals are separated with the network filter inside the speaker and routed to each unit. However, group delay occurs between the units due to this processing through the network filter. Using a microphone, Full Band Phase Control automatically measures and analyzes the group delay that occurs across the whole frequency range, then compensates only the phase characteristics without affecting the frequency characteristics, by adjusting with a FIR filter. As a result, multi-way speakers sound coherent like full-range speakers, while retaining their advantage of the wide frequency range—a significant advancement in sound quality.



When the frequency range is separated via the network filter on a multi-way speaker, although the total frequency characteristic is designed to be flat, the phase and group delay characteristics are not flat. As shown on right, Full Band Phase Control solves this in three steps by using the MCACC microphone and DSP to measure, analyze, and make compensations.

Frequency Characteristic and Impulse Response of a General 3-Way Speaker



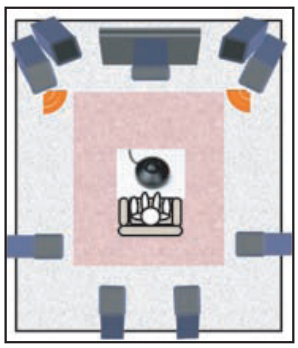
Because of group delay due to the network filter, the sound output order is: high-range, mid-range, low-range.

The phase and group delay adjustment of Full Band Phase Control is applied not only to each speaker unit—simultaneous analysis and compensation is also made between all connected speakers. So even on a setup consisting of speakers from various brands or series with completely different characteristics, you can enjoy a natural and seamless performance as if delivered all from the same speakers. With accurate sound reproduction for the full bandwidth in all channels, Full Band Phase Control creates the ideal sound field for multi-channel reproduction with unprecedentedly clear audio localization and a tremendous surrounding sound.

Three-Step Processing within the AV Receiver

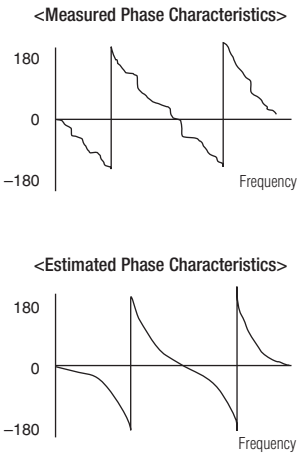
Measurement Step 1

- Special sweep signal output from each speaker
- Signals measured with dedicated mic
- Digital Signal Processing (DSP) of measured signals
- Impulse response gained from each speaker



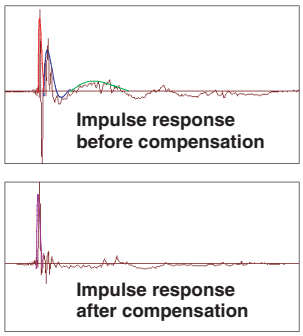
Measurement Step 2

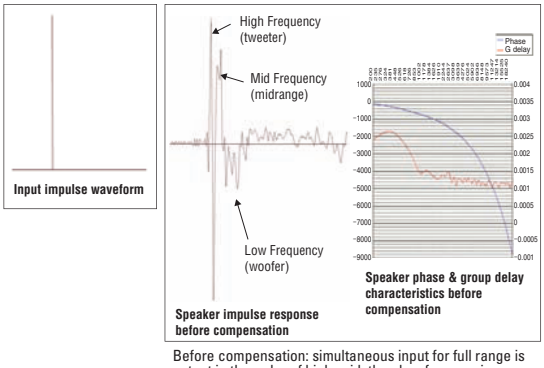
- Calculate phase characteristics from impulse response
- Extract the optimal model from the approx. 5,500 phase models (99 % of the commercially available speakers)
  - ◆ Less influence from room environment
  - ◆ Avoiding overcompensation allows adjustment without deteriorating sound quality
- Calculate the inverse filter factor for adjusting the selected phase model
  - ◆ Allows compensation for only the phase component by creating an all-pass FIR filter



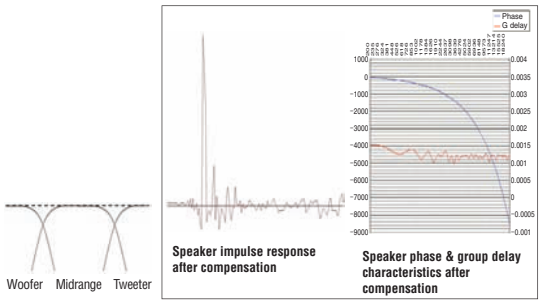
Measurement Step 3

- Apply FIR filter with the calculated filter factor to each channel
- Phase and group delay for each speaker is adjusted to have the ideal characteristics of a full-range speaker
- Sound field with matched phase and group delay characteristics for all speakers achieved




Input impulse waveform
High Frequency (tweeter)
Mid Frequency (midrange)
Low Frequency (woofer)
Speaker impulse response before compensation
Speaker phase & group delay characteristics before compensation

Before compensation: simultaneous input for full range is output in the order of high, mid, then low frequencies



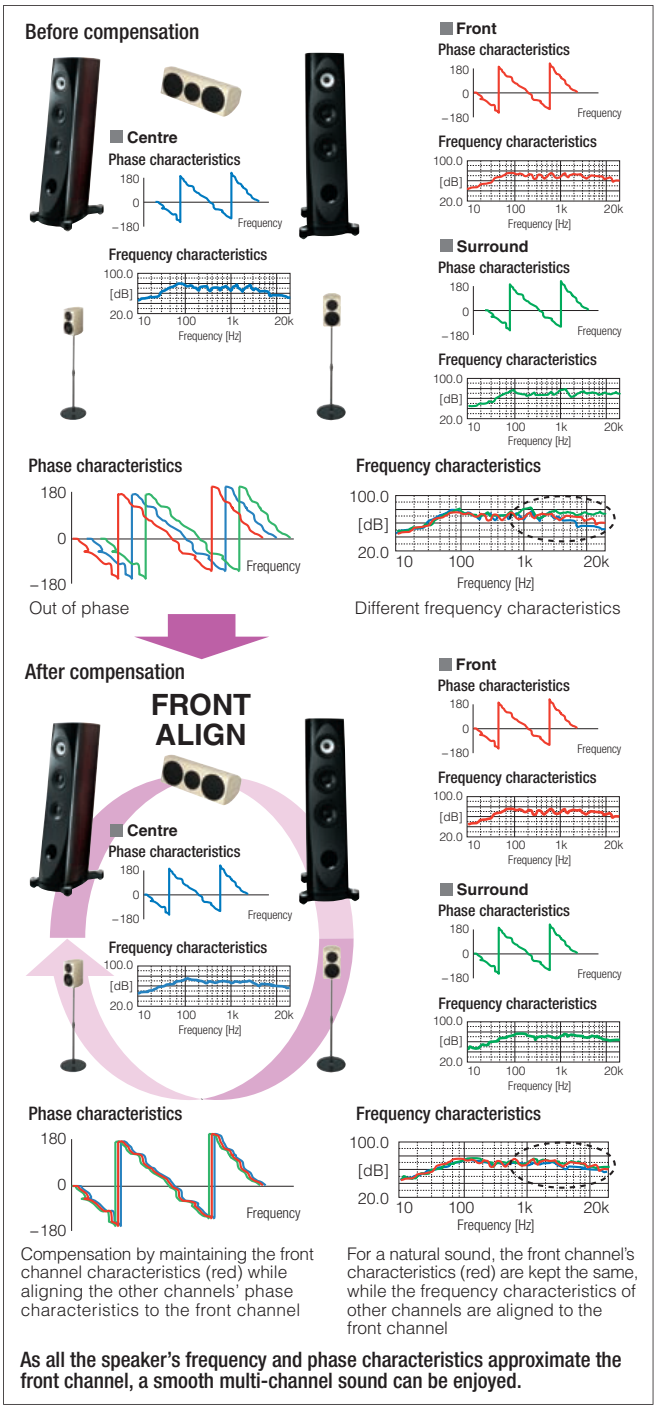
After compensation: simultaneous input for full range results in simultaneous output for all frequencies

Group Delay Compensation Effect

Front Align—Additional Feature for Full Band Phase Control

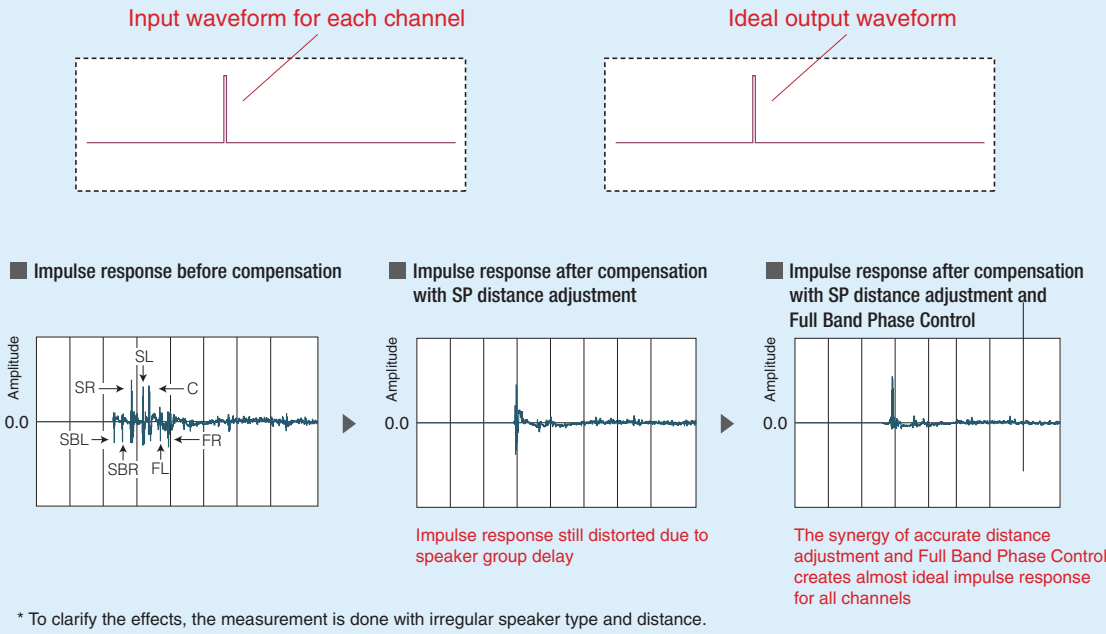
Many users like to create a speaker system with the emphasis on the front speakers for music playback. Front Align is a new feature added to Full Band Phase Control that matches the phase characteristic of all speakers to the front speakers. By combining with the existing "FRONT ALIGN" EQ, you can match both the frequency and phase characteristics to the front speakers. This allows you to create a surround sound field with a smooth feel, with focus on your favorite front speakers.

Front Align Setup Image



As all the speaker's frequency and phase characteristics approximate the front channel, a smooth multi-channel sound can be enjoyed.

The Synergy of Accurate Distance Adjustment and Full Band Phase Control



* To clarify the effects, the measurement is done with irregular speaker type and distance.

Even with the same impulse input for each channel, the response waveform will be distorted without proper settings and speaker drive control. By aligning the speakers through accurate speaker distance measurement, and matching the timing across the frequency range with Full Band Phase Control, an ideal reproduction environment is created where the timing for all channels for the full bandwidth is matched.